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Modelling of electrical characteristics of a photovoltaic module Helios SFB-15-15 in Matlab/Simulink

Abstract

The paper considers a standalone model based on the mathematical relations between various parameters in a photovoltaic (PV) module made up of a single diode, series resistance, and a shunt resistance. The effect of solar radiation and temperature on I-V and P-V characteristics of the PV module has been studied. Matlab/Simulink software package has been used for PV module modelling. The results obtained are analysed and presented in the paper.

Key words: PV electrical characteristics, single-diode model, Matlab/Simulink.

1. Introduction

Photovoltaics is the technology that generates direct current (DC) electrical power from semiconductors under illumination by photons. Photovoltaic cells have one operating point (that is, voltage and current) at which they are of maximum power. Thus, PV power electronics is to maintain continuously the maximum power point. Therefore, the modelling of electrical characteristics of PV cells I-V and P-V is important in order to determine this point. In this paper, a photovoltaic module model, based on values provided by the manufacturer's data sheet, suitable for various values of temperature and irradiance is presented.

2. PV Module modeling

2.1. PV module Helios SFB-15-15

The PV module Helios SFB-15-15 (fig. 1) is monocrystalline silicon panels, produced by Research Institute of Semiconductor Devices, JSC, Tomsk, Russia. The advantages of the module Helios SFB-15-15 is a foldable design, easy to operate in different places.

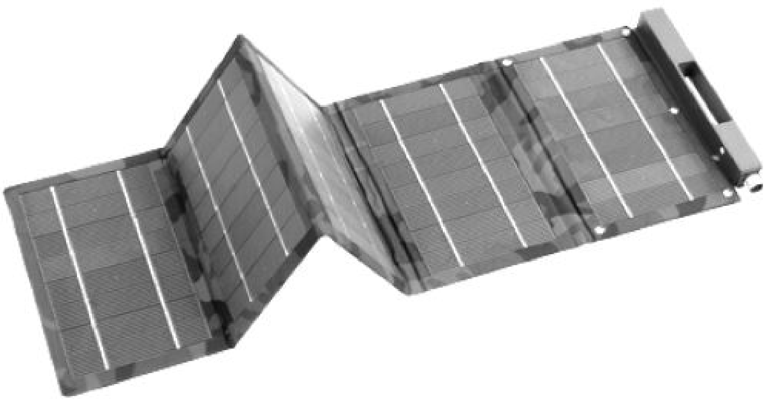

Fig. 1. Photovoltaic module Helios SFB-15-15

2.2. Classical single-diode model

PV cells are usually represented by a simplified equivalent circuit model such as given in fig. 2 or by equation as in formula (1) [1, p. 92]:

$$I = I_{ph} - I_0 \cdot (e^{\frac{q \cdot (U + I \cdot R_S)}{A \cdot k \cdot T}} - 1), \quad (1)$$

where the symbols are defined as follows:

I_{ph} is photocurrent, A

I_0 is saturation current, A
R_{sh} is shun resistance, Ohm
R_s is series resistance, Ohm
U is thermal voltage, V
k is Boltzmann's constant $(1.38 \cdot 10^{-23})$
q is electron charge $(1.602 \cdot 10^{-19} C)$

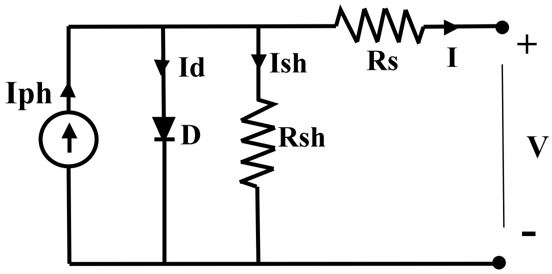

Fig. 2. Simplified equivalent circuit of the photovoltaic cell

2.3. Modelling of the PV module Helios SFB-15-15 in Matlab/Simulink

The input parameters of the model contain the values from the data sheet of the PV module of Helios SFB-15-15 type. These parameters are considered in standard test conditions (irradiance of 1000 W/m^2, module temperature of 25 °C) [2]:

Maximum Power, Pmax = 15 W
Voltage at Maximum Power, Vmp = 18.5 V
Current at Maximum Power, Imp = 0.81 A
Open Circuit Voltage, Voc = 23.6 V
Short Circuit Current, Isc = 0.84 A
Temperature Coefficient of Voc, Tv = -1.23×10^{-4} V/°C
Temperature Coefficient of Isc, Ti = 3.18×10^{-3} A/°C
The PV module model is shown in fig. 3:

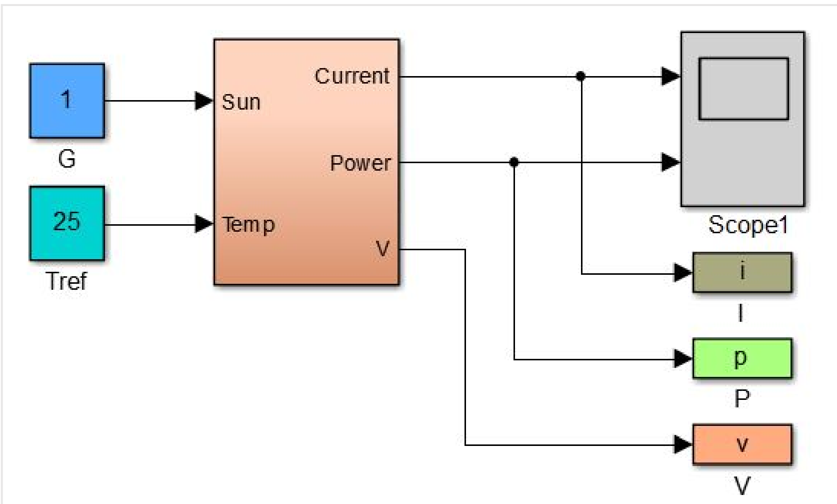

Fig. 3. Operational functional block diagram of the PV module model

3. Simulation results

The current-voltage and power-voltage of the PV module Helios SFB-15-15 with the effect of changing temperature and solar irradiation level is given in fig. 4–7:

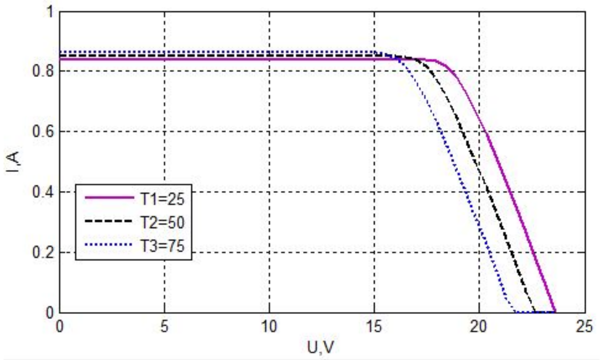

Fig. 4. Current-voltage characteristics at different temperatures

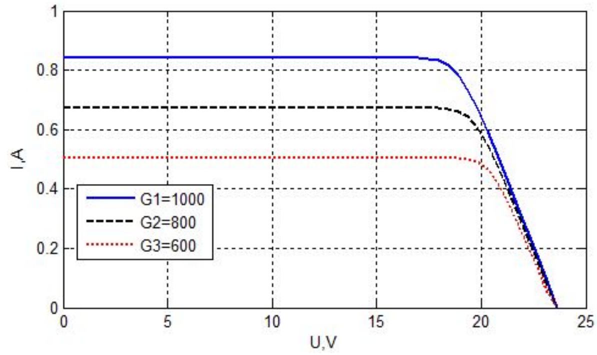

Fig. 5. Current-voltage characteristics at different solar irradiation level

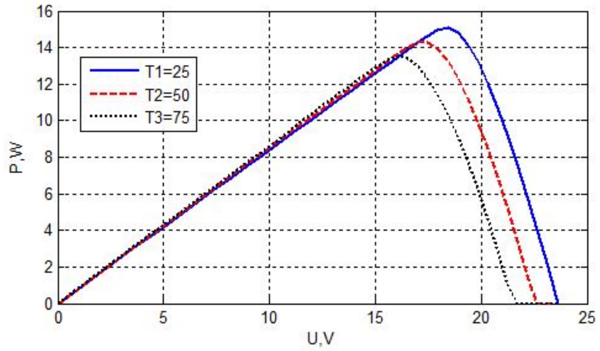

Fig. 6. Power-voltage characteristics at different temperatures

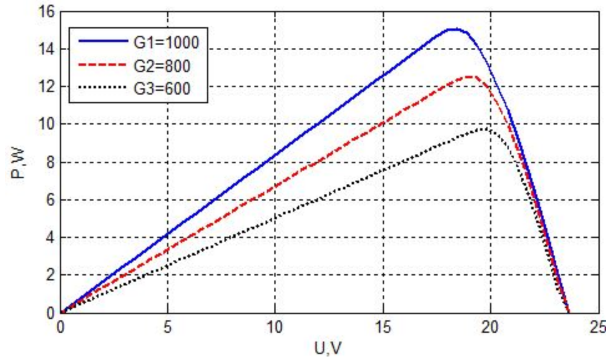

Fig. 7. Power-voltage characteristics at different solar irradiation level

4. Conslusions

This paper introduces the simulation model of PV module Helios SFB-15-15 to be used in Matlab/Simulink environment. Modelling has been performed with changes in temperature and solar irradiation level. This model will be used to develop an algorithm called the maximum power point tracking to determine an optimal operation mode of the PV module.

References

1. Antonio Luque. Handbook of Photovoltaic science and engineering. 2003.
2. Yurchenko A.V, Koslov A.V. Analysis of the solar battery efficiency under natural conditions in Tomsk/ 9th International scientific and practical conference of young scientists. 2013.

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